Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright Patterson Air Force Base, Ohio 45433.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

LONG-LINE LOITER.

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Eric J. Jumper

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
	~~20~~ 21	9

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 7184	AMRL-TR-70-54
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at the Human Engineering Research session of the Psychology of the Air Force Symposium held at the USAF Academy, Colorado, 31 March thru 2 April 1970.	Aerospace Medical Research Laboratory, AMD, AFSC, Wright-Patterson Air Force Base, Ohio 45433.

13. ABSTRACT

JUL 13 1972

C

Several free-fall and circling-line techniques have been studied by the Flight Environments Branch. These techniques enable a fixed-wing aircraft to remotely place and retrieve objects above or on the ground at near zero velocity. Such maneuvers introduce new concepts in performing selected communication, supply, rescue, reconnaissance and strike missions. A single airborne system having high-velocity and zero-velocity components can fly unique missions that neither a fixed-wing aircraft, nor a helicopter are capable of flying.

DD FORM 1473

LONG-LINE LOITER

ERIC J. JUMPER

Flight Environments Branch
Human Engineering Division
6570th Aerospace Medical Research Laboratory
Wright-Patterson AFB, Ohio

Several free-fall and circling-line techniques have been studied by the Flight Environments Branch. These techniques enable a fixed-wing aircraft to remotely place and retrieve objects above or on the ground at near zero velocity. Such maneuvers introduce new concepts in performing selected communication, supply, rescue, reconnaissance and strike missions. A single airborne system having high-velocity and zero-velocity components can fly unique missions that neither a fixed-wing aircraft, nor a helicopter are capable of flying.

INTRODUCTION

The Aerospace Medical Research Laboratory has proved the worth of the on-pylon turn maneuver when used in the side-firing concept, as an effective Air Force strike tactic. In studying that concept, it was found that a point could be easily tracked using only a single mark on the windshield (Reference 1). Since the original study of the side-firing concept, the on-pylon turn maneuver has been examined as a means of positioning a mass on or over a ground point and/or retrieving a mass from the ground. This paper describes several long-line concepts, gives a short history of the circling-line concept, tells what we have done in this area, and presents some of the applications now being developed.

The air-to-ground link is achieved by combining the on-pylon turn with what is known as the circling-line phenomena. A long line (anywhere from 1500 feet to several thousand feet, depending on the mission) towed behind an orbiting fixed wing aircraft, will under certain conditions, assume a spiralling inverted cone path with the free end at the vertex (Figures 1 and 2). The conditions which must be met are functions of aircraft speed, orbit radius, line length, and mass size and weight, and although the combination of these factors is complex, the conditions are not extremely restricting. The system, is capable of two basic modes: a hovering point above the ground in the case when the vortex is above the ground, and a line in contact with a ground point when the vortex is at ground level or below. Thus, the same aircraft speed, orbit radius, and line length could be used for either mode by simply changing the aircraft altitude. A launch of the mass is effected by the aircraft simply flying out of orbit and either flying straight and level, or gaining altitude (Figure 3).

HISTORY

As near as we can tell, something resembling the Long-Line Loiter systems was toyed with as far back as the 1940s (Reference 2), but very little can be found actually describing any tests until the 1950s. One of the earliest good [illegible] of the circling-line

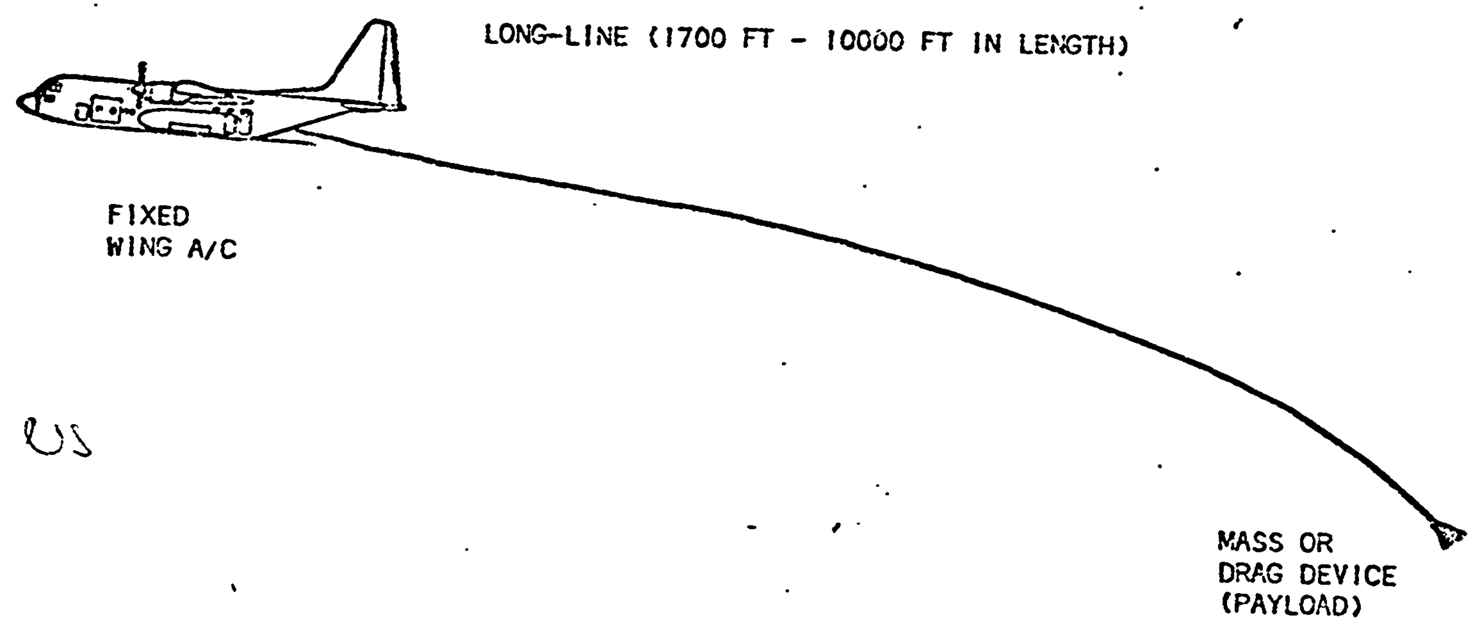

FIGURE 1: BASIC LONG-LINE SYSTEM

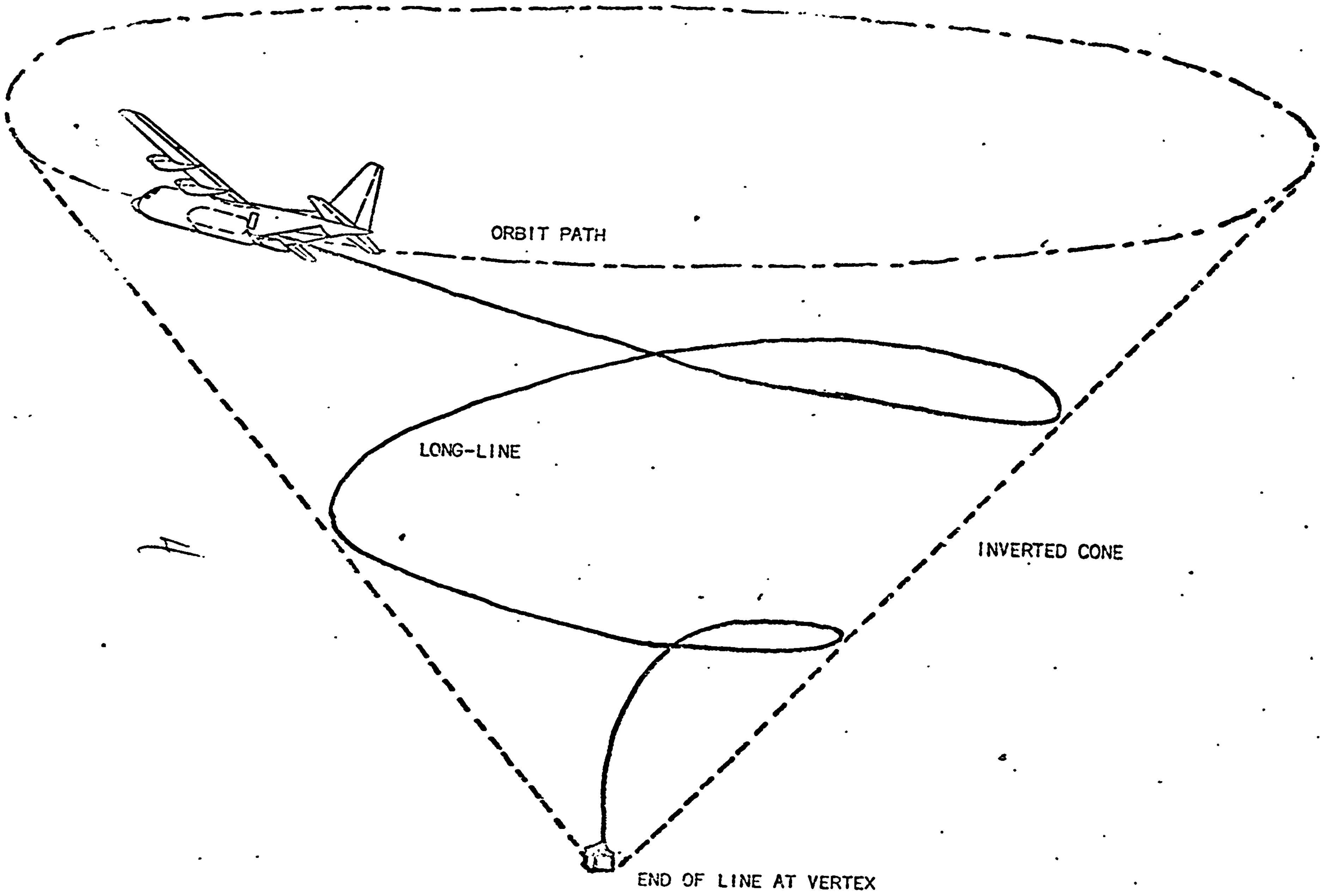

FIGURE 2: CIRCLING LINE PHENOMENA

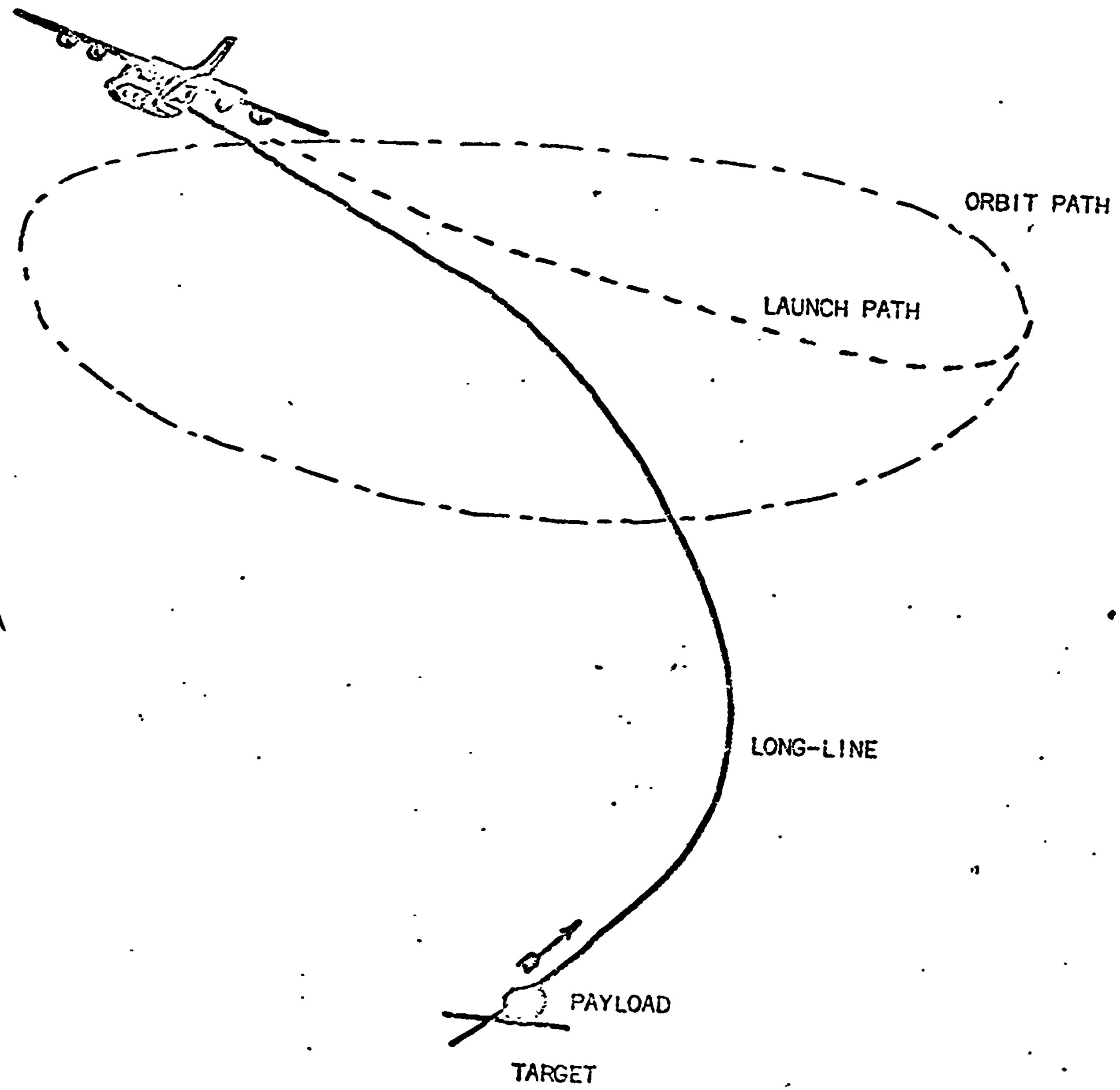

FIGURE 3: LAUNCH MANEUVER

phenomena is that by a pilot-missionary named Lawrence Bradford Saint. He independently conceived of, flight tested, and used the concept in his missionary work in the jungles of Northeastern Ecuador. Saint was one of five missionaries slain by spears in Ecuador by Auca Indians in 1956. The following are selections of Saint's account of his work in circling-line (References 3 & 4):

> "Jungle flying often presents the problem of supplying a missionary stationed or marooned in a spot far from a landing field. Nate had experimented with parachuting supplies under such circumstances. Shifting wind currents sometimes carried the loaded chutes to a high tree or to an inaccessible part of the jungle. Other times, the chute failed to open. There was the problem too, of communicating with the person on the ground. Hand and body signals could not always be understood."
>
> "Then he thought back to the day at Wheaton when he sat daydreaming as he watched his pencil swinging from a string."
>
> "'The idea struck me like the silver lining under a hunk of cumulus,' Nate said. 'A helper

went along to manage the items of equipment. We took off for our first tests. The bucket was tied securely on one end of the cord and lowered from the door of the plane. One end of the line was tied to the plane so that there would be no unanticipated complications if the line should become snagged. It would simply break.'"

"When Nate returned to the United States for his first furlough, he carried on further tests of the bucket-drop at an airfield in the Los Angeles area."

"'While Henry Walton, a friend, was letting out the line, he said, 'I circled at about 1000 feet. The circles had to be large ones, but now with the bucket some 1500 feet behind us, we were ready for the test. It is like fly testing with a 2000-foot pole.'"

"'I banked and turned more sharply, gradually making the circle smaller while we watched the bucket. Like an obedient caboose on the end of an invisible train, it followed in our wake. Finally, strange as it seemed, the bucket was directly opposite us, though a little lower, travelling in the opposite

7

direction! It seemed completely independent, just mimicking our pattern of flight.'"

"'As I turned still more sharply, a curious thing began to happen. Up till that time the bucket had travelled about sixty miles an hour. Now it began to move more slowly. The large arc of cord behind it was finally bending in toward the center of our circle permitting the bucket to settle downward toward the point of a huge invisible cone.'"

"'As the bucket dropped earthward, it seemed to lose all horizontal motion. Finally, it came to rest quietly in the middle of the open field below.'"

"'Then we climbed a little, still circling,' Nate continued. 'The bucket obediently lifted from the ground and hovered.'"

"'We were now equipped with more than the old canvas bucket, having acquired a pair of field telephones and 1500 feet of wire... with fellow missionary Bob Hart in the plane to help, we took off, and in due time arrived over the village. Frank had already arrived on foot. We circled and saw him waving to us.'"

"'We proceeded to unreel the wire at the end of which was the phone was nestled in the bucket. It dropped right into the clearing at the center of the village.'"

"'Hello, Frank,' Nate's passenger spoke into the phone in the plane, 'this is Bob Hart.'"

"While Hart talked for several minutes to Mathis, Nate relayed over the plane's short-wave radio to a doctor in Quito, nearly two hundred miles away, the symptoms of stomach ache, headache, leg cramps, cold extremities, and clenched teeth. They learned that Mathis was not in danger, so flew back to Shell Mara for the medicine the doctor had prescribed for the sick Indians."

"Shortly after this proof that the bucket-drop had practical implications, Nate and Bob Hart had an opportunity to demonstrate the aerial phone to the president of Ecuador. Both of the missionaries talked to the president himself as the Ecuadorian flag floated overhead 'without a flagpole.'"

"'We have been wondering,' Nate said, 'about the possibility of an amplification of the rig being

9

capable of rescuing a human being. I think that it is entirely possible, but should be approached rather seriously, with responsible engineering help. It is a fascinating subject and although I haven't consulted our dog yet, I believe he is going to 'volunteer' to demonstrate how useful the technique could be.'"

In later years, the circling-line concept was studied by the Army, Navy, Air Force and NASA (References 5, 6, 7, 8) for jobs such as supply, personnel delivery, rescue, reconnaissance and Gemini capsule recovery. All efforts were abandoned for the same reason, inability to position the end of the line accurately. A major problem lies in the response time between changing the aircraft maneuver and mass response. This time can be anywhere from 30 seconds to conceivably several minutes.

FLIGHT ENVIRONMENTS' ROLE

The Flight Environments Branch first looked at the phenomena in the Spring of 1968. Within a month a major breakthrough on ground positioning was developed. The delivery technique is now called Double-Line Free-Fall delivery method, and is affected by double deploying the line (1500 feet of line to 2500 feet or more) as shown in Figure 4, holding the mass in the aircraft, and level bombing the mass into the ground target (500 feet to 2000 feet AGL

[illegible]

angle turn is started to hold the line in a stalled condition, [illegible]

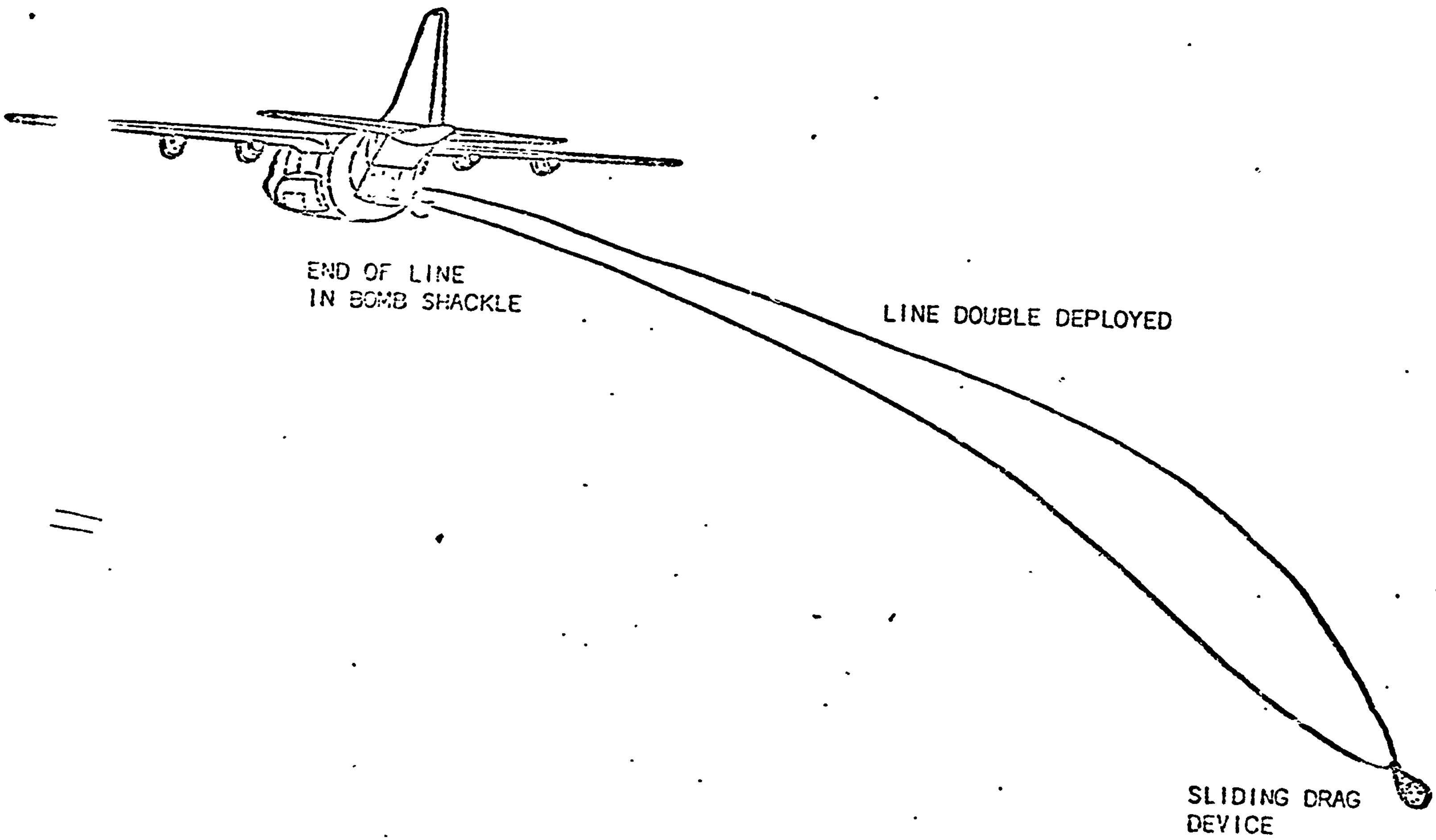

FIGURE 4: DOUBLE LINE DEPLOYMENT

thereafter changing to a constant radius turn with center at the target. With only a simple bomb site, accuracy of within 20 feet of the target has been achieved from 2000 feet AGL in a 15 knot wind.

Two further Branch developments in the Long-Line state-of-the-art are worth mentioning. The first is known as the Para-Loiter technique. This technique is achieved by modifying the basic system to include an opened parachute just above the mass with the apex of the chute attached to the line (Figure 5). With this arrangement, the chute is streamlined while in tow but, as the aircraft goes into orbit and the line begins to stall causing the mass to drop, and the chute will blossom (Reference 9). The mass can then be allowed to fall all the way to the ground (soft landing with chute open) or allowed to drop for a ways and then retrailed and the maneuver repeated as many times as desired.

The second technique is known as the Double-Mass, Double-Line system. This requires a modification to the basic system to include a second mass in the line (anywhere from 100 feet to 1000 feet from the low mass) as shown in Figure 6. When the system is in loiter, the low mass acts as an anchor and the low line an anchor line to keep the high mass stationed over the ground position at a height compatible with the length of the low line.

With the aircraft maneuvers tested and documented, and most of the early application investigations well underway, some near completion

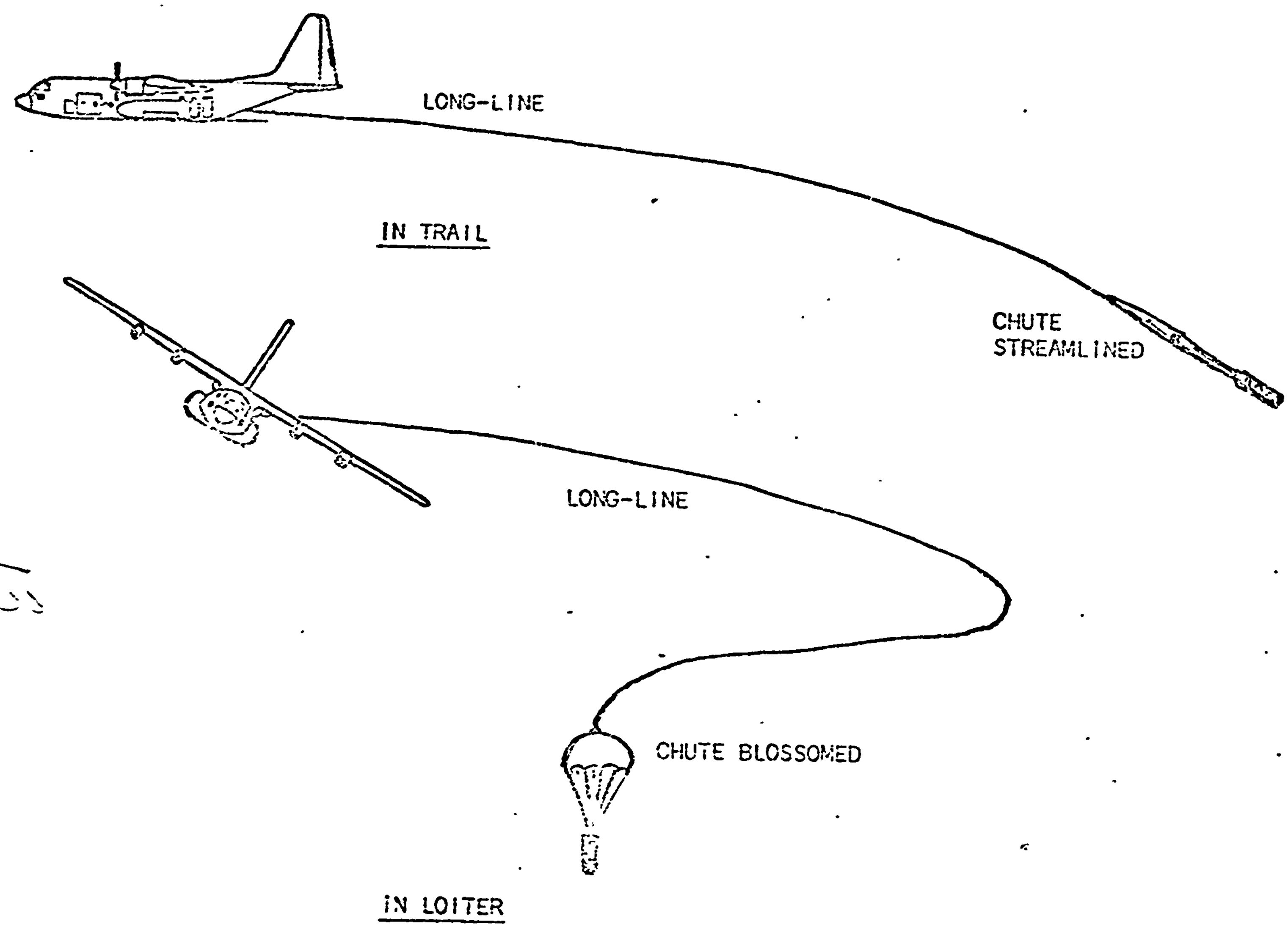

FIGURE 5: PARA-LOITER TECHNIQUE

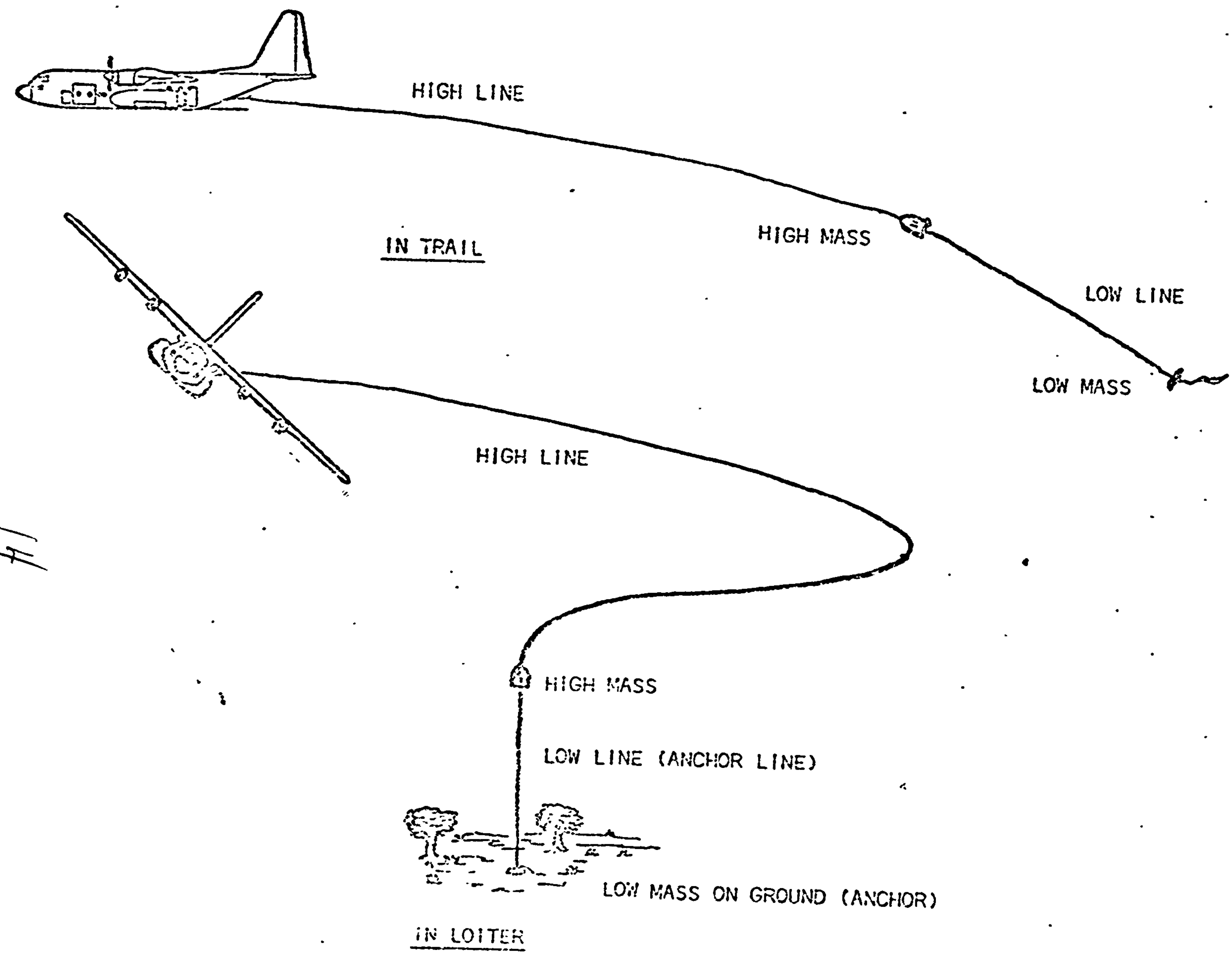

FIGURE 6: DOUBLE-MASS, DOUBLE-LINE SYSTEM

efforts will be geared toward the development of an automated long-line maneuver with inputs to the aircraft autopilot or a pilot display.

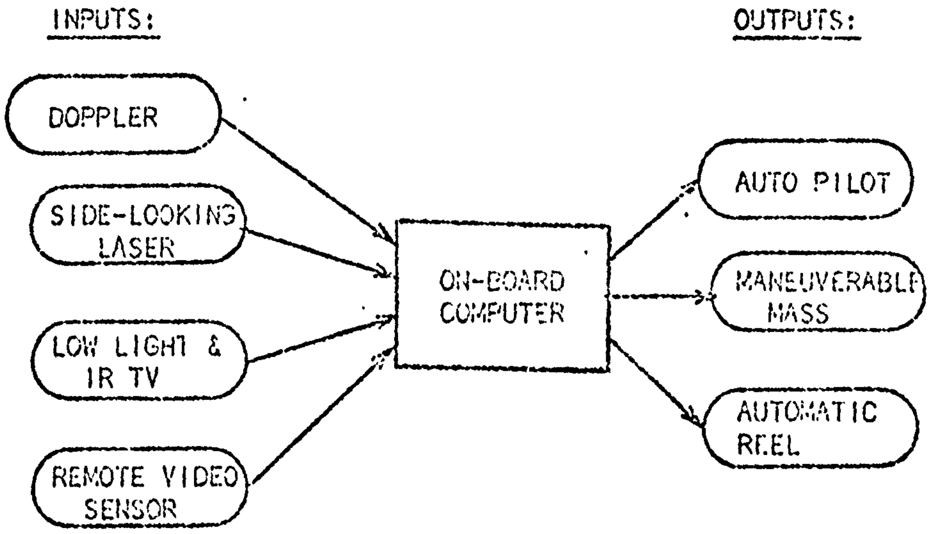

FIGURE 7: AUTOMATIC LONG-LINE SYSTEM

Components such as a controllable and instrumented mass, automatic reel, Doppler radar and a side-looking laser are being studied as input factors for an on-board computer to accomplish this task (Figure 7). Flight testing of concepts toward this end will begin in the Summer of 1970 in a C-130 aircraft flown at Wright-Patterson AFB, Ohio.

APPLICATIONS

The applications presently under study are not so different

15

communication, re-supply, and rescue as well as investigation into such typically Air Force missions as reconnaissance and strike.

A. Communications

Based on flight test data, hardware has been acquired for a long-phone system consisting of a hot mike and headset to be dropped to a ground observer with a nylon line containing hard wire core for the ground-to-air connection. Upon completion of the field testing of this hardware, recommendations for a communication kit willbe made for eventual use by commando, covert Forward Air Controller, rescue and special Military Advisory Groups (Reference 9).

B. Supply

The re-supply application is probably the most evident and easily augmented application for the Long-Line system. Just as Saint was unable to reach his missionary outposts by airplane, so today in places such as a hilltop in Vietnam, pilots are unable to deliver cargo, ammunition, and medical supplies, to say nothing of retrieving the wounded. Many times helicopters are too vulnerable to risk landing and parachutes are to unpredictable to assure landing supplies in a small perimeter. With positioning the end of the line accurately no longer a problem, a direct line can be connected between the air and the ground with the aircraft [illegible] Cargo and supplies can then be slid down the line. Once the delivery of the supplies is complete, the same line can be used to launch supplies, wounded, etc., the size of which depending only on line strength and aircraft tow capability.

C. Rescue

A Long-Line Rescue System is another self-evident application. Two such systems are now under study by the Branch, they are a small aircraft pick-up and re-drop system, and a large aircraft pick-up and retrieval system. The first is the most easily augmented and is at present in the final stages of man rating. It consists of dropping a low mass made up of a packed chute and insulated suit to the man to be rescued. He then need only get into the gear and signal to the aircraft to be launched. At some later time (over a waiting rescue team) he pulls a D-ring which releases him from the line and a static line activates his chute. Due to the simplicity of the system, no heavy equipment such as a large winch is necessary and thus, as mentioned before, it can be used by small aircraft of the Army U-6 Beaver class, with equipment developed by the Branch (See Figure 8).

Although an intermediate pick-up and retrieval system using a small aircraft has been proposed, a system using a C-119 or C-130 is now on the drawing board. A similar low mass as used in the re-drop system is dropped to downed airmen, and again, he donns the [illegible]. Once launched, however,

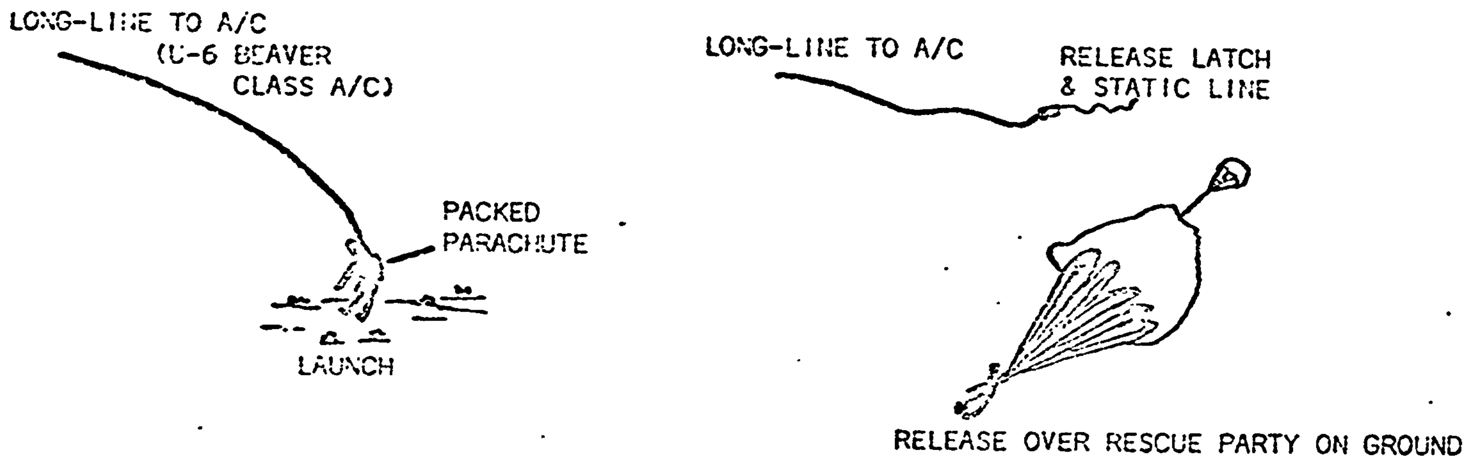

FIGURE 8: SMALL AIRCRAFT RE-DROP RESCUE SYSTEM

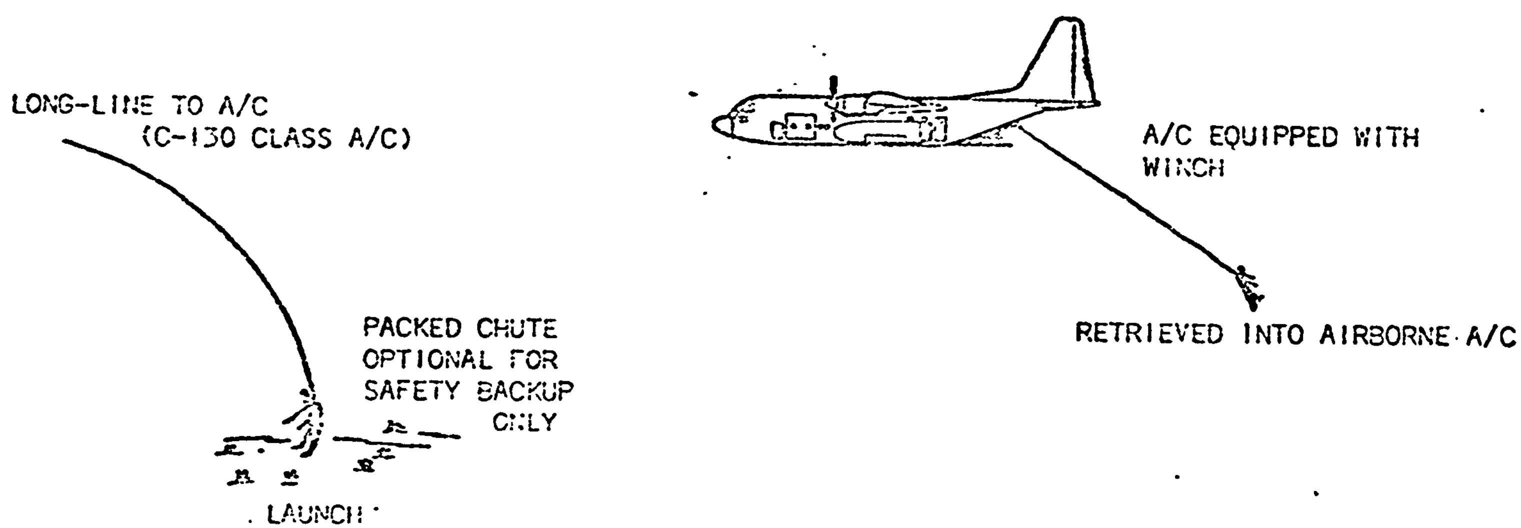

FIGURE 9: LARGE AIRCRAFT RETRIEVAL RESCUE SYSTEM

the man is reeled into the aircraft using a large winch. In this respect, it is similar to the Fulton Pick-Up System now in the Air Force Inventory (See Figure 9). Flight testing of this system is planned to begin in the Fall of 1970.

D. Reconnaissance and Strike

Previously, the Air Force had to choose between high speed or near zero velocity (fixed wing aircraft vs rotary wing aircraft). The Long-Line not only combines high speed/high altitude and near zero velocity/low altitude into the same system, but allows both phenomena to occur simultaneously. In terms of reconnaissance and strike this means combining the accuracy of a low altitude stable platform with the decreased vulnerability of a high altitude/high velocity fixed wing aircraft. It also allows covert operations and for the first time, encourages reconnaissance and strike missions in weather conditions which previously would have prohibited flights of this nature.

REFERENCES

1. Simons, J. C., et al; Project Tailchaser: Development of a Lateral Firing Concept, AMRL-TR-66-202, Wright-Patterson Air Force Base, Ohio; November 1967.

2. "Initial Circular Flying Pick-Up Lines", ATI No. 46126, Dayton, Ohio; December 1948.

3. Hitt, Russell T., Jungle Pilot: The Life and Witness of Nate Saint, Harper and Brothers, New York, 1959.

4. McIntyre, Loren, "Ecuador: Low and Lofty Land Astride the Equator", National Geographic, Vol 133, No. 2, February 1968, pg 294.

5. Battelle Memorial Institute Project No. G-6561-3003, Travel Report Dated 19 May 1966.

6. "Feasibility Investigation of the Yo-Yo Personnel Retrieval System", ER3406, October 1958.

7. E. L. White, et al, Study of Heavy Equipment Aerial Delivery and Retrieval Techniques, AFFDL-TR-65-97, Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio; January 1967.

8. "Surface-to-Air Retrieval of Heavy Spacecraft by Fixed Wing Aircraft, Volume I - Initial Feasibility Studies", PDR 306-1, Prepared for the NASA Manned Spacecraft Center, June 1962.

9. Simons, J. C., Dixon, B., Long-Line Loiter: Improvement of Some Free-Fall and Circling-Line Techniques. ASD-TR-69-95, Volume I, September 1969.